# Science

# Module 10

# Life Science: Structure and Function/Growth and Development

## Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Cells – All living things are made of cells that perform functions necessary for life.

## Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module unit.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module unit.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Life Science: Structure and Function/Growth and Development and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Connecting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

# Section I

## Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and related Alternate Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex

understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs and UCs for Life Science: Structure and Function/Growth and Development. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

**Table 1. Science Academic Standards and Related AATs and UCs** [1]

| Academic Standards | Alternate Assessment Targets (AAT) | Underlying Concepts (UC) |
|---|---|---|
| ***Cells – All living things are made of cells that perform functions necessary for life.*** | | |
| **3210.1.6** Determine the relationship between cell growth and cell reproduction. | Use a model to identify how growth occurs when cells multiply. | Recognize that organisms are composed of cells. |
| **3210.1.3** Distinguish among proteins, carbohydrates, lipids, and nucleic acids. | Identify how the digestive system of the body carries out essential functions (i.e., breakdown and absorption of fats, proteins, and carbohydrates). | Recognize that different organs in the digestive system have different functions. |
| **3210.1.5** Identify how enzymes control chemical reactions in the body. | Identify how different organisms react to changes (e.g., heart rate, body temperature). | Compare data on changes that occur to an organism before and after exercise. |

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs and UCs listed in Table 1.

# Section II

## Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts, but rather it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K – 12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices, as appropriate, to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. See Section VI. Universal Design for Learning

Suggestions for support ideas. Following are the eight science and engineering practices (National Research Council, 2012) with added examples.

- Asking questions (for science) and defining problems (for engineering).
  *Examples: How do cells help my body grow? What occurs during cell division? What are the four stages of food processing? Why do I get warmer when I exercise? Will my heart rate get faster the longer I exercise?*
- Developing and using models.
  *Examples: Use a model to illustrate mitosis. Model peristalsis using a plastic straw and bead by pinching the bead down through the straw. Develop a model of chemical digestion including enzymes.*
- Planning and carrying out investigations.
  *Examples: Conduct an experiment to observe the process of cell multiplication (i.e., mitosis) using garlic or onion roots. Conduct an investigation that illustrates the breakdown of food in digestion (e.g., digestion of starch by amylase). Conduct an investigation showing how the body reacts to exercise (e.g., breathing and heart rate increase; body temperature rises).*
- Analyzing and interpreting data.
  *Examples: Use data to illustrate the multiplication of cells. Record and analyze heart rate and minutes of exercise to determine the body's reaction to exercise.*
- Using mathematics and computational thinking.
  *Examples: Design a way to test whether protein digestion is affected by the size of the food pieces using a data table for recording observations. Measure someone's temperature before, during, and after exercise.*
- Constructing explanations (for science) and designing solutions (for engineering).
  *Examples: Explain that all organisms are composed of cells. Explain the digestive system's function and how that relates both to the system's parts and to the overall function of the organism.*
- Engaging in argument from evidence.
  *Examples: Use reasoning to explain why the ability of organisms to reproduce their kind is the one characteristic that best distinguishes living things from nonliving matter on a cellular basis. Use appropriate evidence to explain why a person may sweat during exercise.*
- Obtaining, evaluating, and communicating information.
  *Examples: Interpret data showing the effect of the temperature of the environment on a person's skin temperature and body temperature to develop hypotheses and make predictions. Consider the foods advertised to children and their nutritional value to communicate the issue, analyze options, and propose a solution.*

### Science Practices Resources[1]

This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. http://www.justsciencenow.com/inquiry/

Serendip studio provides a variety of hands-on activities for teaching biology to high school or middle school students. http://serendip.brynmawr.edu/sci_edu/waldron/

[1] The resources in this module may change over time and no longer be available.

Fun Science Gallery provides a lab experiment illustrating mitosis using garlic or onion roots. http://www.funsci.com/fun3_en/mitosis/garlic.htm

Seattle pi has experiments that illustrate the digestive system. http://education.seattlepi.com/digestive-system-experiments-seventh-graders-6613.html

Better Lesson provides an investigation on the body's reaction to exercise. http://betterlesson.com/community/document/94453/exercise-homeostasis-lab

# Section III

## Connecting Concepts

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Connecting Concepts are a common link between multiple standards and units of study. The Connecting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. For example, understanding that a system (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) working together can explain how the interaction between systems provides specific functions in multicellular organisms. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., patterns in mathematics).

### Teaching Connecting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Connecting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., Point out the pattern of breathing faster after exercising compared to when resting.),
- critical features (e.g., Emphasize that large food molecules must be digested and absorbed in order to enter the cells and provide the needed nutrients.),
- big ideas (e.g., Cell division enables multi-cellular organisms, including humans, to grow and develop from a single cell, the fertilized egg.), and
- relationships (e.g., Make the connection between stress and homeostasis.).

For example, illustrate that when people exercise their body converts food into energy which produces heat. In order for their body to remain stable, the body releases extra heat in the form of sweat.

Following are **Connecting Concepts** for this Content Module – Life Science: Structure and Function/Growth and Development.

**Understand**

**Patterns**

- Patterns can be used to determine similarities and differences.
- Patterns can be observed and used as evidence.
- Patterns can be used to identify cause-and-effect relationships.

**Cause and Effect**

- Events that occur together with regularity might or might not have a cause-and-effect relationship.
- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change.

**Scale, proportion, and quantity**

- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Models using scale can be used to study systems that are too large or too small.

**Systems and System Models**

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- System parts work together.

**Structure and Function**

- Different materials have different substructures, which can sometimes be observed.
- The function of complex and microscopic structures and systems depends on the shapes, composition, and relationships among its parts.

**Energy and Matter**

- Energy cannot be created or destroyed; it only moves between systems, one place and another, or between objects.
- Matter is made of particles and energy that can be transferred in various ways and between objects.
- Energy drives the motion and/or cycling of matter.

**Stability and Change**

- Changes in one part of a system might cause large changes in another part.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.
- Matter is conserved because atoms are conserved in physical and chemical processes.

## Connecting Concept Resources:

Grant Wiggins talks about “big ideas” in this article.
http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99

TeacherVision provides ten science graphic organizers that are free and printable.
https://www.teachervision.com/graphic-organizers/science/52539.html

Utah Education Network provides a variety of student interactives for grades seven through twelve.
http://www.uen.org/7-12interactives/science.shtml

# Section IV

## Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., digestion) and in the context of the specific content (e.g., Teach the terms "esophagus," "stomach," "small intestine," and "large intestine" while illustrating the process in which the body breaks down food.).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize to a variety of the body's systems. For example, understanding the meaning of the word "system" helps students to connect different systems of the body that function together. The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words, such as "mitosis," connect to general words related to the reason for, and process of, mitosis (e.g., cell, grow, multiply, repair). Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

### Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three through eight; refer to the TN science standards to identify grade-specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., The heart pumps blood through our body.) and an example of the word (e.g., My heart beats faster when I exercise.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Mitosis is when a cell divides to make two identical cells.) and a possible connection to a general vocabulary word (e.g., Mitosis is the way our body grows and repairs itself.).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should learn to describe what the stomach does (e.g., it helps digest food) instead of defining the word "stomach."

**Table 2. General Vocabulary Words**

| **General Vocabulary –** words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., heat – a form of energy that feels warm or hot. *Example: My body puts out heat when I exercise.).* | | | |
|---|---|---|---|
| • blood | • excretion | • molecule | • proteins |
| • body | • exercise | • mouth | • repair |
| • calorie | • grow | • mucus | • replication |
| • carbohydrates | • heat | • multiply | • saliva |
| • cell | • hormone | • muscle | • small intestine |

| | | | |
|---|---|---|---|
| • cell cycle | • kidney | • nucleic acids | • stomach |
| • consume | • large intestine | • nutrients | • sweat |
| • digestion | • lipids | • organ | • system |
| • energy | • liver | • organism | • temperature |
| • enzyme | • metabolism | • oxygen | • waste |
| • esophagus | • minerals | • pancreas | |

**Table 3. Specific Content Words**

**Specific Content Words –** words that specify a particular thing (e.g., parent cell) or phenomena (e.g., cell division). Describe the word and when possible make the connection to a Connecting Concept (e.g., A parent cell divides and results in two daughter cells. This cause-and-effect relationship repeats itself as each daughter cell grows and becomes a parent cell.).

| | | |
|---|---|---|
| • activation energy | • epiglottis | • peristalsis |
| • amino acid | • gallbladder | • product |
| • cell division | • heart rate | • respiratory system |
| • chemical reaction | • homeostasis | • substrate |
| • circulatory system | • meiosis | |
| • daughter cell | • metabolic pathway | |
| • digestive system | • mitosis | |
| • DNA | • parent cell | |

## Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

**Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)**[2]

| Ideas | Examples |
|---|---|
| Explain, describe, and/or give examples of the vocabulary word rather than formal definitions. | • Provide a description/example of the digestive system, "The digestive system includes the parts of the body that break down the food we eat." |
| Have students connect new vocabulary, especially general vocabulary, to prior knowledge. | • Have students connect (verbally or using alternative and augmentative communication [AAC] system) the term "nutrients" to previous health instruction on nutrition. |
| Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models). | • Ask students to complete a digital vocabulary activity on the parts of the digestive system (see Figure 1), providing support as needed (e.g., help from peer or adult, adapted mouse, etc.).<br>• Create cell division word wall. Include images of the steps of cell division. Have students add to the word wall with information located in resources, drawings of cell division, etc. |
| Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials. | • Expose students by incorporating vocabulary into daily activities when it is appropriate (e.g., Discuss the ways a person's body reacts to exercise when students have participated in a physical activity. Talk about the role enzymes play in the reactions.).<br>• Have students review flashcards that include images and recorded definitions (e.g., https://quizlet.com/165651815/enzyme-flash-cards/).<br>• Have students watch a video on enzymes (e.g., https://www.youtube.com/watch?v=wp_yyDEEC3k or https://www.youtube.com/watch?v=myORDWVzNhc). |

| Ideas | Examples |
|---|---|
| Ask students to discuss the vocabulary words with each other. | • Have students use their preferred mode of communication to share examples of words (e.g., A cut healing is an example of when mitosis occurs). Adapt by placing examples of the vocabulary words on a voice output device and have the student share with a classmate.<br>• Have students share their representations (e.g., drawings or pictures) of a word with each other. |
| Play vocabulary word games with students. | • Have students play an online game/activity (e.g., https://www.quia.com/cz/119431.html?AP_rand=1905399663 or https://www.brainpop.com/games/buildabodydigestivesystem/).<br>• Have students match a description or representative picture to a word.<br>• Create puzzles using relevant vocabulary (e.g., http://www.discoveryeducation.com/free-puzzlemaker/?CFID=13581564&CFTOKEN=30166776). |
| Have students watch a dramatization or have them act out the vocabulary term. | • Act out the steps in digestion (e.g., https://www.youtube.com/watch?v=G6IoL0-qhD0) or cell division (e.g., https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1449698/). |

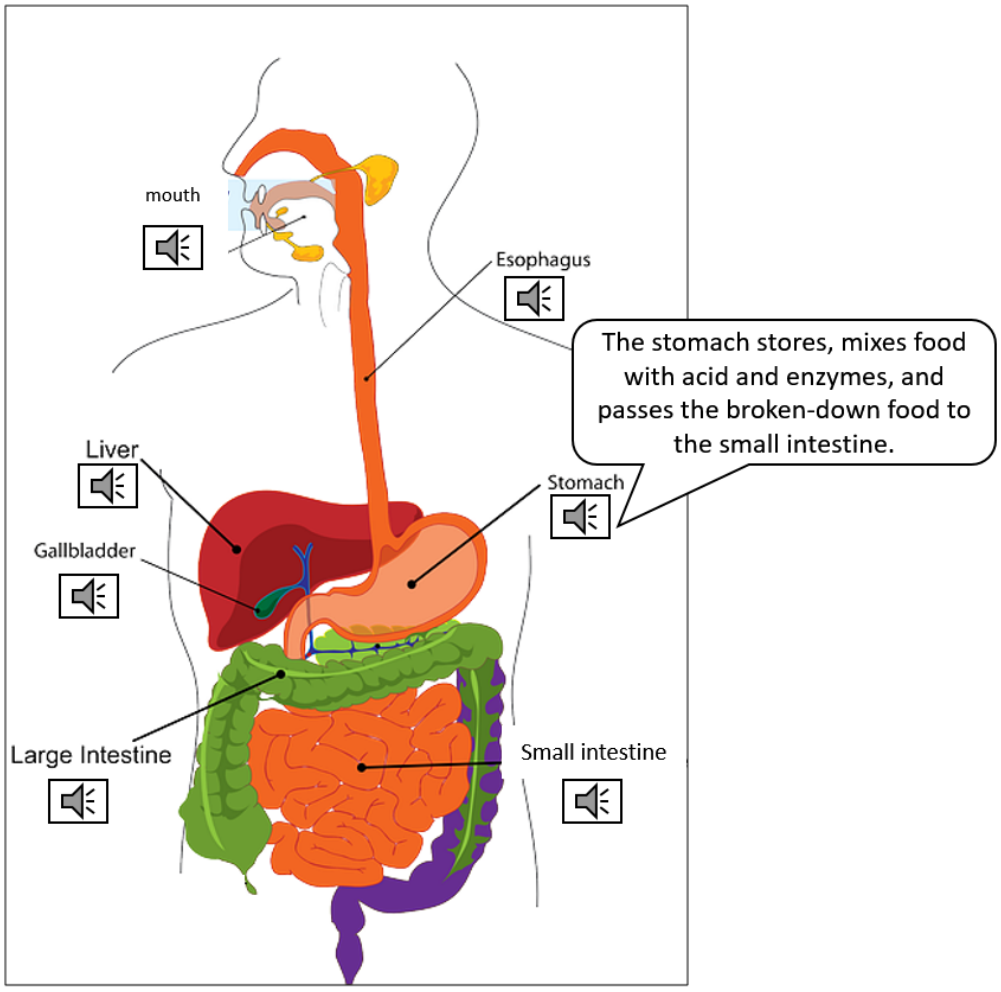
[2] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

### Vocabulary Example

Have students explore a digital model of the digestive system that provides a prerecorded name and description of each organ when selected (see Figure 1). Educators may need to support, modify, or adapt steps as needed for individual students. For example, read everything to the student, provide an adapted mouse, paper version using textures, etc. Two National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

**Figure 1. Example Digital Vocabulary Activity**




## Vocabulary Resources:

Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/

Text Project provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas, including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/

This site provides effective strategies for teaching science vocabulary. http://www.learnnc.org/lp/pages/7079

The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

This article explains the power of using interactive word walls and provides examples for science. http://static.nsta.org/files/ss1103_45.pdf

# Section V

## Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the AATs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

**Cells –** All living things are made of cells that perform functions necessary for life.

**Content**

Proteins, Carbohydrates, Lipids, and Nucleic Acids – Their Role in Digestion

- There are six essential nutrients: carbohydrates, fats, proteins, vitamins, minerals and water.
- The food we eat is the source of three basic categories of molecules important for living organisms:
  - carbohydrates – fast source of energy,
  - lipids (fats) – long term source of energy, and
  - proteins – source for building muscle, the immune system, and providing enzymes.
- Nucleic acids – molecules made of carbon, oxygen, hydrogen, nitrogen, and phosphorus, that contain instructions that cells need to carry out all functions of life. The two types are DNA and RNA. They differ from the other macronutrients in that they are not a source of calories in your diet. Their role is to direct the synthesis of new protein molecules.
- Carbohydrates, lipids (fats), and proteins all provide the body with energy. When nutrients are used by the body for energy, the amount of energy they release can be measured in units called calories.
- The digestive system is a group of organs that breaks down the carbohydrates, lipids (fats), proteins, and nucleic acids of consumed food into their subunits and changes them into nutrients for the body's use.
- The digestive system has three main functions:
  - First, it breaks down food into molecules the body can use.
  - Then, the molecules are absorbed into the blood and carried throughout the body.
  - Finally, wastes are eliminated from the body.
- The digestive system includes the mouth, esophagus, stomach, small intestine, liver, pancreas, and large intestine.
- Each organ has a different function and works together to digest food (e.g., the mouth ingests food and begins the digestive process by chewing).

Enzymes, Chemical Reactions, and the Body's Reaction to Change

- Organisms react to change (e.g., activity level).
- Enzymes are important to functions of the body.
  - Enzymes (mostly proteins) are catalysts that reduce the energy required for a reaction to occur.
  - Enzymes speed up chemical reactions which convert molecules to product molecules.
- Specific enzymes:
  - break down substances and release energy (e.g., digestion) or
  - consume energy (e.g., muscle growth).
- Metabolism depends on enzymes to control chemical reactions.

- Metabolism is the amount of energy the body extracts, stores, and uses from nutrients to maintain itself.
- The body must maintain homeostasis in order for the body's metabolism to work properly.
- Homeostasis is the process by which an organism's internal environment is kept stable in spite of changes in the external environment.
- To maintain homeostasis when exercising, the body reacts by increased:
  - breathing rate to provide enough oxygen for the energy used by the muscles,
  - heart rate to pump the oxygenated blood to the muscles, and
  - body temperature, resulting in sweating to release heat from the body.
- Stress is an organism's reaction to threatening, challenging, or disturbing events. During stress, the body releases a chemical called adrenaline. Adrenaline gives you a burst of energy and causes many other changes in your body.

Cell Growth and Cell Reproduction

- Cells make up all living organisms.
- The quantity of cells grows by multiplying.
- The regular sequence of growth and division that cells undergo is known as the cell cycle.
- The cell cycle is divided into three main stages:
  - Interphase – the cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.
  - Mitosis – one copy of the DNA is distributed into each of the two daughter cells.
  - Cytokinesis – the cytoplasm divides, distributing the organelles into each of the two new cells.
- A parent cell develops and divides into two daughter cells.
- Each daughter cell repeats the process, creating more cells.
- There are two types of cell division:
  - cells divide to help organisms grow and repair (mitosis) and
  - cells divide to help organisms reproduce and create new organisms (meiosis).
- Models can be used to illustrate cell division and multiplication (e.g., pipe cleaners to represent the position of chromosomes at different stages of mitosis).

### Unit Content Resources:

Perkins School for the Blind has short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

Proteins, Carbohydrates, Lipids, and Nucleic Acids – Their Role in Digestion

- The Inner Body has information on the digestive system including interactive models. http://www.innerbody.com/image/digeov.html
- This video explains the four biological molecules and how we get these through food. https://www.youtube.com/watch?v=YO244P1e9QM
- The National Institute of Diabetes and Digestive and Kidney Diseases provides information on the digestive system and how it works. https://www.niddk.nih.gov/health-information/health-topics/Anatomy/your-digestive-system/Pages/anatomy.aspx
- This site provides a hands-on lesson plan on the digestive system. http://mypages.iit.edu/~smile/bi9706.html

- This site provides a unit lesson on the organ systems of the human body including the digestive system. http://theinnerhuman.weebly.com/digestive-system.html

Enzymes, Chemical Reactions, and the Body's Reaction to Change

- The Tennessee Curriculum Center has lesson plans on enzymes. http://www.tncurriculumcenter.org/concept/Enzyme
- This site has information on energy regulators: enzymes and ATP. https://www.cliffsnotes.com/study-guides/biology/plant-biology/energy-and-plant-metabolism/energy-regulators-enzymes-and-atp
- Chem4Kids provides information on enzymes. http://www.chem4kids.com/files/bio_enzymes.html
- This site explains the effects of exercise on homeostasis. http://www.livestrong.com/article/480961-the-effect-of-exercise-on-homeostasis/
- These sites provide activities to measure the effect of exercise on homeostasis.
  - http://betterlesson.com/community/document/94453/exercise-homeostasis-lab
  - http://www.wfisd.net/cms/lib/TX01000557/Centricity/Domain/2487/Homeostasis%20Lab-%20The%20Effects%20of%20Exercise.pdf
- This site explains the relationship between homeostasis, metabolism, and enzymes. http://www.wisegeek.com/what-is-the-relationship-between-homeostasis-and-metabolism.htm
- This site provides information on cell metabolism. http://www.nature.com/scitable/topicpage/cell-metabolism-14026182

Cell Growth and Cell Reproduction

- This site provides information on cell growth and division, including images, a time lapse video, and models. https://askabiologist.asu.edu/content/cell-division
- This site has the big idea of mitosis. https://www.reference.com/science/mitosis-occur-4d6fe937748de4ca?qo=contentSimilarQuestions
- This site provides information on mitosis. http://www.yourgenome.org/facts/what-is-mitosis
- Science-Class has many resources for teaching cell division. http://science-class.net/archive/science-class/Biology/Cell_Division.htm

# Section VI

## Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization.

Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**:

providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding.

Table **7** provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for these needs:

**V** = visually impaired (low vision, blind, or deaf-blind)
**H** = hearing impaired (deaf, hard of hearing, or deaf-blind)
**P** = physical disability (limited use of hands)

**Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation**

| Multiple Means of Representation | |
|---|---|
| **Strategies** | **Examples** |
| Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile). | Have students use a simple model representing the length and sequence of each organ in the digestive system (e.g., http://www.perkinselearning.org/accessible-science/digestive-system-model-demonstrating-sequence-and-length-organs). **V**<br>Have students complete hands-on activities that demonstrate how digestion begins in the mouth (e.g., http://www.sciencecrazy.co.uk/single-post/2015/05/08/The-Digestive-System).<br>Prepare models of each organ of the digestive system (e.g., https://pixabay.com/en/digestion-intestine-digestive-oral-303364/) using a unique color and texture for each. Have students place the organs in a model of the body. **V** |
| Model content through pictures, dramatization, videos, etc. | Watch a video on:<br>• enzymes and digesting (e.g., https://www.youtube.com/watch?v=XTUm-75-PL4),<br>• exercise and breathing rate (e.g., https://www.youtube.com/watch?v=FyhYHlA7bZw),<br>• mitosis (e.g., https://www.youtube.com/watch?v=gwcwSZIfKlM).<br>Act out how a cell divides (e.g., https://www.youtube.com/watch?v=ZEwddr9ho-4). |
| Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures). | Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (Here's a slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P**<br>Have students put images of mitosis in the correct order (e.g., http://www4.esc13.net/uploads/science/docs/manipulatives/mitosis_line_up.pdf).<br>Have students sort names, images, or representative objects of objects and organisms into those made of cells and those not made of cells. |
| Provide appropriate and accessible text on the content for students to listen to or read. | Have students read/listen to an online text about metabolism and enzymes (e.g., http://kidshealth.org/en/parents/metabolism.html) and the digestive system (e.g., https://kidshealth.org/en/kids/digestive-system.html). |
| Teach information using songs. | Teach content using songs<br>• enzymes (e.g., https://www.youtube.com/watch?v=NdMVRL4oaUo),<br>• digestion (e.g., https://www.youtube.com/watch?v=0O8wrhEzDtI), and<br>• mitosis (e.g., https://www.youtube.com/watch?v=IlV9hExXZnM). |

**Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression**

| Multiple Means of Action and Expression | |
|---|---|
| **Strategies** | **Examples** |
| Use assistive technology to allow the student to interact with the instructional materials and content. | Have students use an adapted mouse to drag labels of organs to the correct organs on a diagram of the digestive system (e.g., http://www.softschools.com/science/human_body/digestive_system/). **P**<br>Have students listen to pre-recorded information on cell division using a single or double message adaptive switch. **P**<br>Have students use a tactile graph (see Section VIII, Tactile Maps and Graphics for guidance) to graph breathing and heart rate before, during, and after exercising. **V**<br>Have students use a talking thermometer in an activity about homeostasis (e.g., http://www.perkinselearning.org/accessible-science/human-body-regulation). |
| Present instructional materials in a manner that provides access. | Place printed text and pictures on a slant board. **V/P**<br>Provide hand-on-hand exploration of a cell division model. **V/P**<br>Provide students a template and sentences paired with representative images to choose from to complete a daily exercise journal that includes recording breathing and heart rate before and after exercising.<br>Place materials for investigations on a tray with a lip to make finding the materials easier. **V** |
| Provide adapted switches, voice output devices, or tactile choices for students to select an answer. | Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. **P**<br>Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then select the correct answer. **V/P**<br>Ask questions that can be answered with yes/no responses or with answer choices using an adapted switch, voice output switch, or tactile representation. |
| Provide simulation activities. | Have students view an animation of mitosis (e.g., http://www.cellsalive.com/mitosis_js.htm). Have students advance the animation using an adaptive switch. **P**<br>Have students build a model of the process of mitosis using textures (e.g., http://www.perkinselearning.org/accessible-science/mitosis-student-built-model). **V** |
| Create a digital graphic organizer that allows drag-and-drop. | Have students use an adapted mouse to drag-and-drop pre-made main idea, details, and vocabulary from biology articles (e.g., http://fitstar.com/happens-muscles-exercise-2/) onto a graphic organizer. **P** |

**Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement**

| Multiple Means of Engagement | |
|---|---|
| **Strategies** | **Examples** |
| Provide a schedule and visual timer. | Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break.<br>Provide a visual and/or auditory cue (e.g., http://pricklypearcoop.schoolwires.com/cms/lib07/MT08000619/Centricity/Domain/8/B.%20Strategies%20for%20Transitions%20in%20School.pdf) to prepare students to transition from one activity to another.<br>Use a first/then schedule (e.g., http://www.autismclassroomresources.com/visual-schedule-series-first-then/). |
| Vary the challenge and amount of information presented at a time. | Introduce breathing and heart rate before and after exercise, then discuss the relationship to chemical changes within cells. |
| Make connections to topics or activities that are motivating. | Ensure activities are age and grade appropriate.<br>Make connections to mitosis using Legos® (e.g., https://www.youtube.com/watch?v=sItqmEOWc18). |
| Allow choices as possible. | Allow students to choose where to work on a task, the tools to use for completing a task, type of reward or recognition for completing a task, etc. |
| Provide opportunities to work collaboratively with peers. | Provide opportunities for students to work in a general education classroom with peers when learning about predicting weather.<br>Include students in general education classroom for all instruction on a topic, not just during experiments. |
| Teach student self-regulation skills. | Provide communication symbols to request a break or express feelings and model how to use them appropriately.<br>Provide students with stress balls, finger fidgets, etc.<br>Have an adult or peer model goal-setting and self-evaluation of identified goals. |

**UDL Resources**

The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org

The UDL Curriculum Toolkit provides two applications for science.
http://udl-toolkit.cast.org/p/applications/l1

Perkins School for the Blind provides life science activities for students who are blind or have low vision.
http://www.perkinselearning.org/accessible-science/activities/life-science

This Perkins School for the Blind video, 20 minutes long, describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec

Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units. www.symbaloo.com

This site provides a brief description of Symbaloo and multiple ways to use the online tool. https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/

Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices. http://www.perkinselearning.org/videos/webcast/tangible-symbols

Perkins school for the Blind has information and tips to make science instruction accessible. http://www.perkinselearning.org/accessible-science/access-tips-science

# Section VII

## Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world applications, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematic skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

**Table 8. Transfer and Generalization Ideas**

| Area | Instruction | Opportunity to Embed Skills |
|---|---|---|
| **Communication** | While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., Discussing health and wellness with the doctor. Discussing feelings of stress with friends and family members.) or understand the concepts (e.g., knowing when increased breathing or heart rate typically occurs and when it could be a sign of a health problem). | Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems. |
| **Reading and Listening Comprehension** | Provide information through reading books and articles (e.g., https://newsela.com/articles/chocolate-health/id/3150/) on science concepts while working on reading comprehension. | Provide practice on communication skills when students are answering questions about the book or article. |
| **Mathematics** | Teach multiplication concepts when determining heart beats per minute by counting beats for 10 seconds and multiplying by 6. | Provide practice on number identification, sequence, relative quantity or size (e.g., which is more?), etc. |
| **Age-Appropriate Social Skills** | Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding cause and effect of exercising). | Provide opportunities to work along same-age peers to practice age-appropriate social skills and serve a vital role in the group. |
| **Independent Work Behaviors** | Encourage and reinforce independent completion of tasks to build independent work skills. | Use positive behavior supports to encourage and reinforce independent work skills. |
| **Skills in Accessing Support Systems** | Encourage students to ask appropriately for assistance from peers and adults when working on the content. | Use this time to have the student work on behavior and communication skills. |

# Section VIII

## Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

## Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science and social studies concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. The following guidance includes information to build upon when creating tactile graphics.

## Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a map to illustrate location of key countries would not need state lines and capital cities and may not need all of the surrounding countries.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., line that indicates a body of water), and remove any that are not.
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a pencil, an example of goods, with a pencil).

## Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science and social studies.

**Graphic Organizers/Concept Maps**

- It is best to present information to compare or make connections in a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

**Diagrams/Models**

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

**Timelines**

- Present timelines in the same direction every time (i.e., horizontal or vertical).

**Maps**

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

## Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

**Commercial products:**

- Capsule paper or swell paper – print
- Thermoform

**Textured shapes can be made from:**

- Sticky back textured papers found at craft stores
- Corrugated cardboard
- Fabric with texture (e.g., corduroy, denim)
- Silk leaves
- Cork
- Felt
- Vinyl
- Mesh tape (used for drywall)
- Sandpaper

**Raised lines can be made from:**

- Glue (best not to use water-based glue)
- Wax pipe cleaners

## Resources

Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided basic principles for Preparing Tactile Graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics

Perkins School for the Blind has short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

Perkins School for the Blind has information on how to use Play-Doh to illustrate science concepts for students who are visually impaired. http://www.perkinselearning.org/videos/teachable-moment/tactile-science-lesson-using-play-doh

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## Picture Citations

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